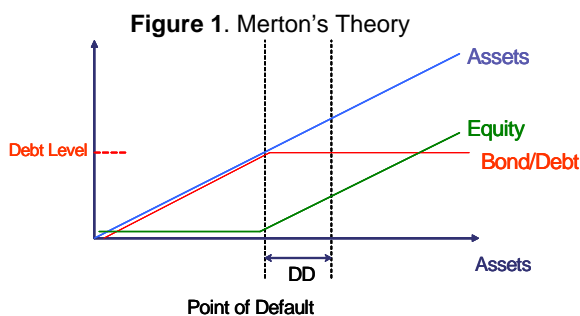


A Note on the Sovereign Credit Risk of Hungary

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Following Merton's option-based debt theory, we estimate the distance-to-default for Hungary's sovereign debt, as described by Gapen et al. (2005). We find that the international sovereign debt market was quite benign to Hungary between 2002 and 2005 as indicated by the country's EMBI spreads. At the same time, the increment in the volatility of the domestic interest rates and the depreciation of the forint highlighted on the increasing sovereign credit risk.

The presented approach is based on Merton's (1974) theory to value corporate debt. This classic theory is based on the shareholders' limited liability. If the company has sufficient assets to pay back its debt to the lenders, the remaining value of the assets is what the equity-holders own. However, if the value of the assets is less than the value of the debt, the company is in default since it cannot completely pay back its obligations. In this case lenders get the total value of the assets, and equity-holders are left with zero value. The payoff diagrams are illustrated in Figure 1.



¹ Treasury of the World Bank and European Commission, DG ECFIN. The findings, interpretations, and conclusions are those of the authors and should not be attributed to the World Bank or the European Commission.

The value of the equity is the same as the payoff diagram of a call option. In other words, the equity-holders' value can be modeled as if they had a call option on the companies assets with an exercise price equal to the company's debt level.

A similar framework can be applied to model sovereign credit risk by replacing the corporate balance sheet by the sovereign balance sheet. The estimation procedure of the probability of sovereign default, the distance to distress, and some additional sovereign credit risk measures is still based on Merton's theory. According to the proposed framework of Gapen et al. (2005), we consider the consolidated sovereign balance sheet as summarized in Figure 2.

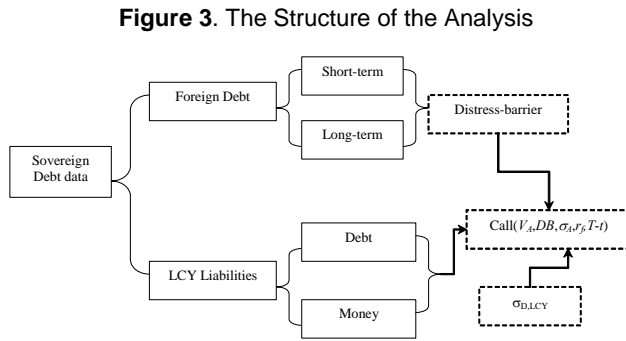
Figure 2. Consolidated Sovereign Balance Sheet in FCY terms

Assets	Liabilities
Local Currency Assets	Local Currency Debt
	Money
Foreign Exch. Reserve	Foreign Currency Debt

Furthermore, we had to make additional assumptions:

- Foreign debt is assumed to be the senior debt. In other words, in the most simplistic setting, this component plays the role of the "classic debt" in Merton's approach. The above mentioned credit risk measures are estimated with regards to the foreign debt.
- Distress barrier is defined as the *total* level of foreign debt.
- Local currency debt, on the other hand, is considered to be the junior debt. Applying the option-theory, this debt component plays the role of "equity". Domestic currency debt, in other words, is assumed to behave like a call option on sovereign assets.

The analytical framework can be summarized in Figure 3:



The formula that we use to value domestic currency debt is the classic Black-Scholes formula to price call options. The exercise price is replaced by the distress barrier (DB):

$$call = V_A \cdot N(d_1) - PV(DB) \cdot N(d_2)$$

$$d_1 = \frac{\ln(V_A / DB) + (r_f + 0.5\sigma_A^2)(T - t)}{\sigma_A \sqrt{T - t}} \quad (1)$$

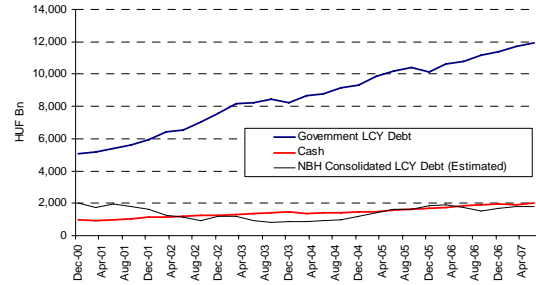
$$d_2 = d_1 - \sigma_A \sqrt{T - t}$$

In fact, the estimation process goes in the reverse order: we can observe the value of domestic debt (measured in EUR terms) that should be equal to the hypothetical call option's value. On the other hand, we cannot observe the value of sovereign assets V_A which is, in fact, the underlying instrument of the option. Similarly, as a function of the currency exchange rate and interest rate fluctuations, we can estimate the volatility of the local currency debt $\sigma_{D,LCY}$ but we cannot directly observe the volatility of the underlying sovereign assets. In order to assess the volatility of the underlying assets, we use the following approximation:

$$V_{D,LCY} \cdot \sigma_{D,LCY} \approx N(d_1) \cdot V_A \cdot \sigma_A \quad (2)$$

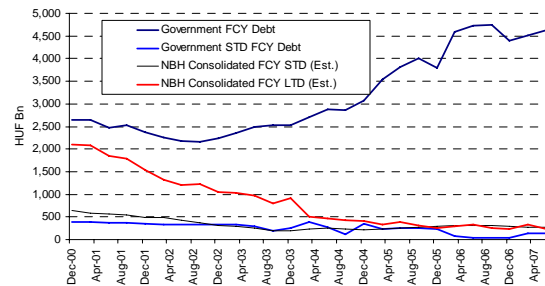
With these expressions in hand, we can now solve the option pricing formula numerically in the reverse order. We applied this approach to the case of Hungary. Figure 4 and Figure 5 summarize the debt statistics that we used for our calculations.

Figure 4. Local Currency Sovereign Debt



Source: National Bank of Hungary and authors' calculation

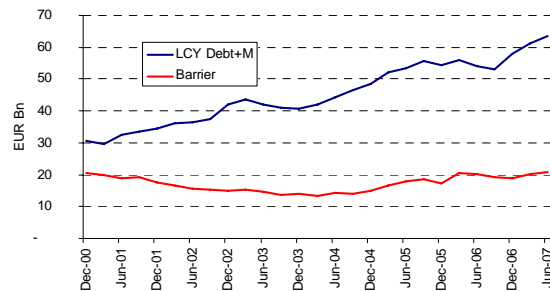
Figure 5. Foreign Currency Sovereign Debt



Source: National Bank of Hungary and Government Debt Management Agency

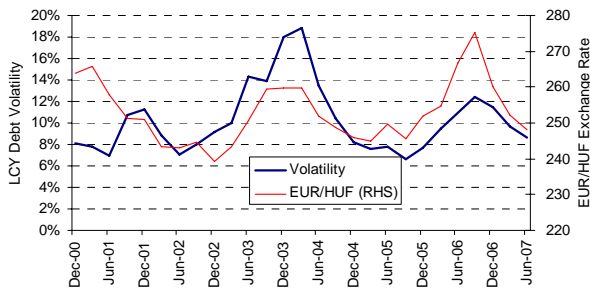
Based on the data presented in the two figures above, we aggregate foreign debt as the "distress barrier", and present the overall sovereign domestic liability as the sum of the local currency debt and the money supply. In the option-based model the distress barrier (i.e. the level of the foreign debt) represents the "exercise price", whereas the value of the domestic liabilities corresponds to the value of the "equity".

Figure 6. Local Currency and Foreign Currency Debt as Distress Barrier



In addition, the volatility of the market value of the local debt expressed in foreign currency also plays a significant role in the model. The two main market risk factors are thus the exchange rate of the forint versus the euro, and the volatility of the domestic government bond yields. The foreign exchange rate and the volatility of the domestic debt are shown in Figure 7.

Figure 7. Market Risk Indicators

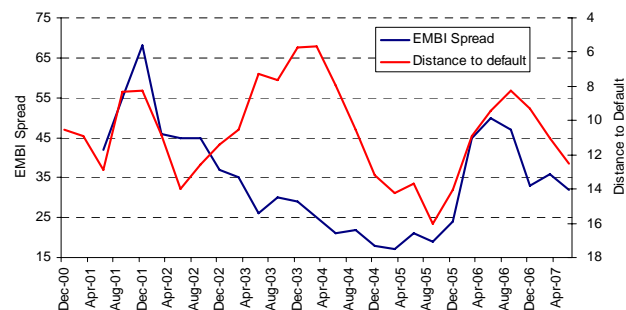


Source: Bloomberg and authors' calculation

Finally, Figure 8 shows the estimated distance to distress, based on the following expression:

$$\text{Dist.to distress} = \frac{\text{Val.Sovgn.Assets} - \text{DistressBarrier}}{\text{Val.Sovgn.Assets} \cdot \sigma_A} \approx d_2 \quad (3)$$

Figure 8. Estimation Result and EMBI Spread



Source: J.P. Morgan and authors' calculation

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MERTON, R.C. (1974): "On the Pricing of Corporate Debt: the Risk Structure of Interest Rates", *Journal of Finance*, Vol. 29, pp. 449-70.

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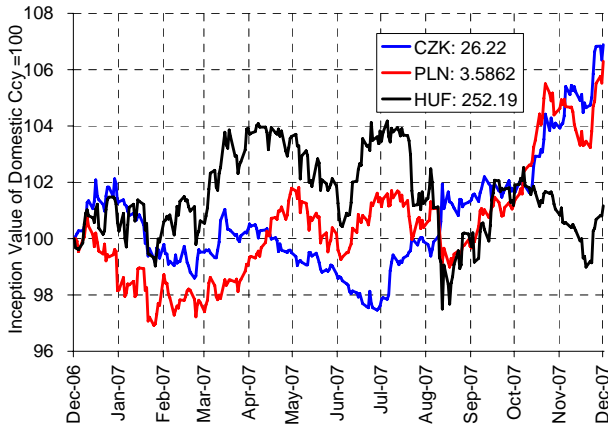
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<http://www.hungarianamerica.com/hunex-econ/>

Currency Markets

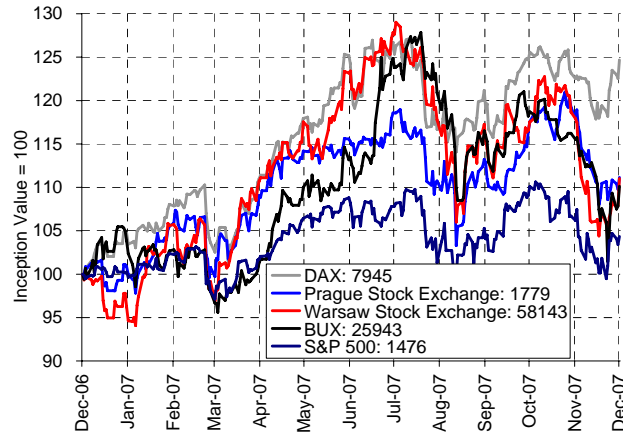
Value of Domestic Currency vs. Euro



Source: Bloomberg

Equity Markets

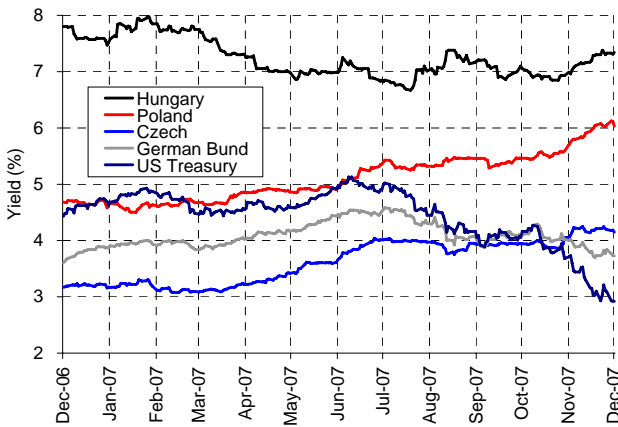
Representative Stock Indices



Source: Bloomberg

Domestic Bond Markets

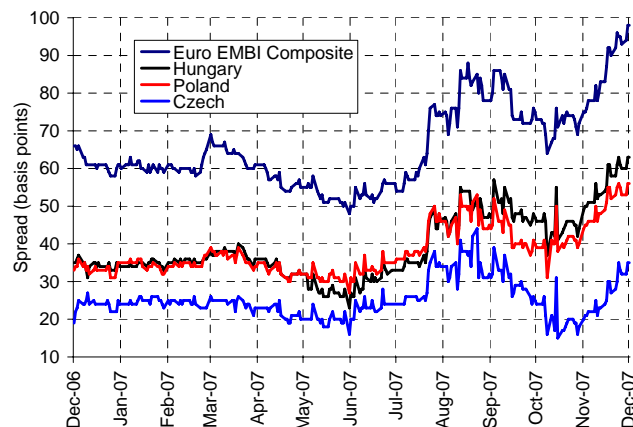
3-Year Government Bonds



Source: Bloomberg

Euro-Denominated Sovereign Bonds

Government Spreads



Source: J.P. Morgan, Bloomberg

Latest Economic Releases: Hungary

Indicator	Last Release	Actual Value	Next Release	Survey Median
NBH Base Rate	11/26/07	7.50	12/17/07	7.50
CPI Monthly	10/31/07	0.80	12/11/07	0.60
CPI Yearly	10/31/07	6.70	12/11/07	7.30
PPI Monthly	11/30/07	0.30		
PPI Yearly	11/30/07	-1.40		
Avg Gross Wages Y/Y	9/30/07	8.60	12/19/07	
GDP YoY (Constant Prices)	11/16/07	1.00	12/7/07	
Industrial Production M/M	11/15/07	0.20	12/6/07	
Industrial Production Y/Y	11/15/07	8.70	12/6/07	9.00
Current Account Q/Q (EUR Mn)	6/30/07	-1,700.00	12/29/07	
Foreign Trade Bal. M/M (EUR Mn)	11/30/07	143.20	12/7/07	-30.00
Consolidated Govt Budg (HUF Bn)	10/31/07	-1,196.90	12/6/07	
Unemployment Rate	11/28/07	7.30		
PMI SA	12/3/07	51.00		
Retail Trade Yearly (%)	11/23/07	-4.60	12/21/07	

Sources: Bloomberg Economic Releases